Analyzing change of eco-environment based on spatial data in the farming-pastoral region of northern China*

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Abstract −**The paper selects 10 kinds of indexes to reflect ecological environment background condition and build the multi-subject spatial database by using ground meteorological data, remote sensing data and DEM. Then methods are illuminated in detail about evaluating eco-environment background condition and analyzing change. Eco-environment background condition is synthetically appraised in 1989 and 1999. Finally, the paper analyzes the spatial distribution, quantitative change, the trend of change, the change region and the dynamic spatial pattern of eco-environment. The results are as follows: (1) The eco-environment background condition becomes worse from southeast to northwest in the farmland-pastoral region of the northern China. (2) The eco-environment background condition deteriorates from 1989 to 1999. (3) In the adjacent area of Jin-Shan-Meng-Gan-Ning, Horqin desert and its outer area, the east Qinghai province, changes of ecological environment are very terrible.**

I. INTRODUCTION

Eco-environment is the homestead of people. However, as a result of intensified human activities and climate changes in the past decades, many regions have been suffering ecological degradation in the world. Fragile eco-environment becomes more vulnerable and unstable in these areas. A lot of research topics have been made in recent years related to ecological security, land use and land cover change, environmental evolution and climate changes. But there is little study about comprehensive background condition of eco-environment.

II. STUDY AREA

The farmland-pastoral region of the northern China covers 10 provinces, 205 countries and its total area is 72.6×104km2 (Figure1). It's a transition zone from arid area to moist area, from plateau area to hilly and plain area, and from pasturage area to agriculture area [1]. The farmland-pastoral region of the northern China is the most serious area facing desertification threatens. It's an important ecological barrier in eastern China; meanwhile it's a bridge or linkage between pasturage and agriculture regions [2].

Due to its natural condition and unreasonable human activities, the ecological problem of this area is very prominent in China [3, 4]. The environment of this area is frangible, sensitive and vulnerable. Its carrying capacity is low and it's difficult to resist human and natural disturbance. So the farmland-pastoral region of the northern China is a typical and ideal zone for studying ecological environment [5, 6].

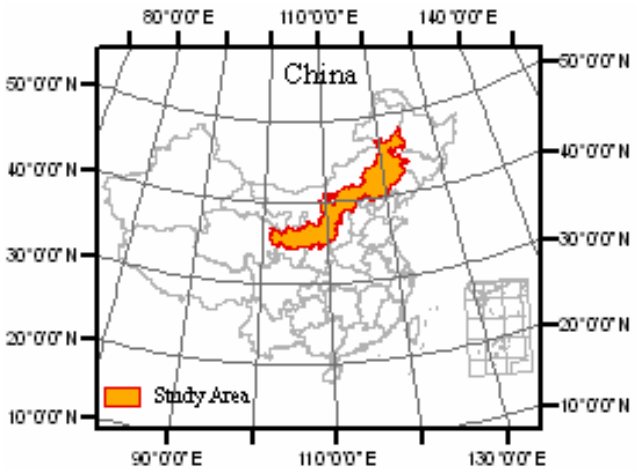

Figure 1. STUDY AREA

III. CRITERIA EVALUATION

The formation and evolvement of regional ecological environment are mainly controlling by a series of external factors such as regional ecological condition, resources base and the extent of social economic development. Rainfall, temperature and their distribution, vegetation development and its community structure, the fundamental characteristics of topography and its spatial pattern directly influence the stability of regional environment and the capacity of natural balance. The factors mentioned above are the fundamental conditions of resources formation. They have negative effects on the changes of regional eco-environment first, then social - ecological development by human activities of resource utilization. So they are the basic factors that constitute the ecological environment [7, 8]. Based on the above influential factors and the data availability at present, this paper selects 10 indexes respectively, for example land use types, vegetation coverage, altitude, slope, rainfall, temperature, accumulated temperature, wind speed, humidity and sunshine hour.

Every index reflects some characteristics of eco-environment, so its contribution is different to construct eco-environment background condition. The domain steps to decide weight are as follows: (1) standard processing raw data; (2) building relative matrix of each index; (3) calculating the character values of relative matrix and vector values of each index. The vector value is weight of each index.

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IV. METHODS

A. Evaluation of Eco-environment

Due to the different resource of data, indexes are quite different in categories and their units are also diverse. So uniform and standardization of all the data must be done before comprehensive evaluation. The uniform of data includes unifying the coordinates system, the data format, the size of each grid and so on. This paper adopts the Albers projection system, the data format is grid and the grid size is 500m×500m. When the data are being standardized, at first each index is classified into several grades, then each grade is assigned a value from low to high according to its contribution to the eco-environment. Meanwhile quantitative expression must be realized based on the uniform criterion in order to make sure that all the indicators in different quantity grades are still impartial and logical when they are calculated in the comprehensive evaluation. After standardization the data of each index is a set of numerical value that can reflect its features and the outcome are between 0-10. Taking the grid as the appraise sub-region, the eco-environment background index can be calculated by overlaying the spatial data.

$$E_p = \sum_{i=1}^{n} W_i \times X_i \quad (1)$$

Where E_P is the eco-environment background index of p appraise sub region; W_i is the quantitative value after i index being standardized; X_i is the weight value of i index according to its contribution to the eco-environment; n is the amount of index.

B. Change Analysis

The dynamic change of regional eco-environment can reflect the change of quantity and its tendency in a definite time in this area.

$$K_j = \frac{\sum_{i=1}^{n} E_b - E_a}{n} \quad (2)$$

$$L = \frac{U_b - U_a}{U_a} \times \frac{1}{T} \times 100\ \% \quad (3)$$

Where K_j is the average change index of eco-environment background in j administrative region in the study period; E_a, E_b are the eco-environment background index at the beginning (1989) and the end (1999) of the study period respectively; n is the total amount of grid of j administrative region; L is the changing degree of a certain grade of eco-environment in the study period; U_a, U_b are the area of a certain grade of eco-environment at the beginning (1989) and the end (1999) of the study period respectively; T is the length of monitoring period.

V. RESULTS

A. Spatial Distributed Pattern of Eco-environment

The distribution of eco-environment background condition in the farmland-pastoral region of the northern China as follow:

The spatial tendency — the eco-environment background condition is getting worse from southeast to northwest. It's better near the farmland region. It's worse by the pastoral region. The eco-environment condition of the region between farmland and pastoral is transition from good to bad (Figure2, Figure3).

The time tendency — the eco-environment background condition is worse from 1989 to 1999. The strength of eco-environment background condition in the farmland is declining gradually. The total area of the region, which its eco-environment is worse, is increasing gradually and there is an obvious tendency that it's expanding to the southeast gradually (Figure2, Figure3).

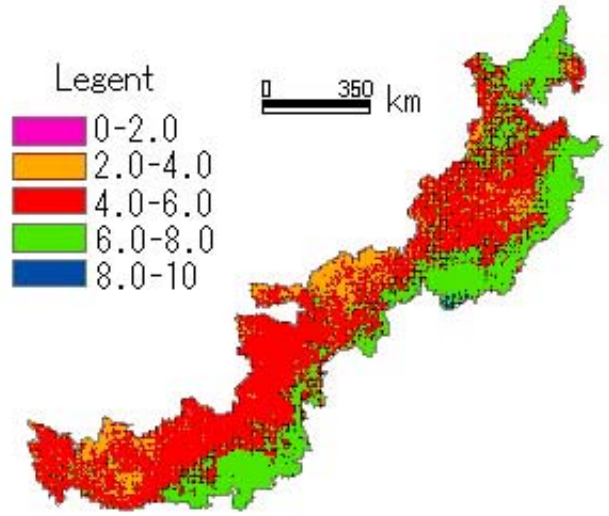


Figure 2. ECO-ENVIRONMENT BACKGROUND CONDITION IN 1989

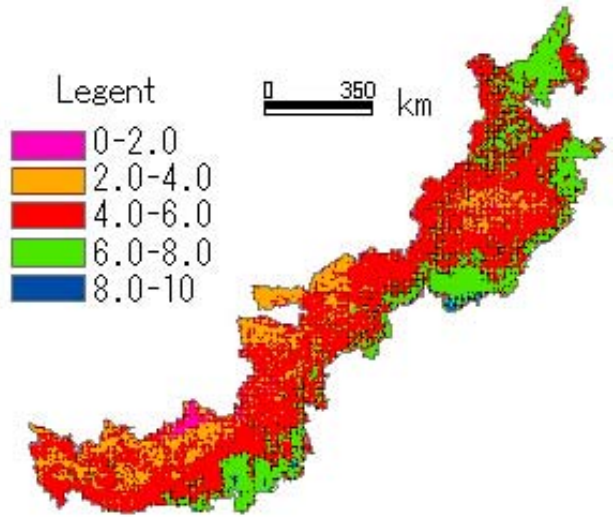


Figure 3. ECO-ENVIRONMENT BACKGROUND CONDITION IN 1999

TABLE I. CHANGES OF ECO-ENVIRONMENT, 1989-1999

Grade	Index	1989 (10^4hm^2)	1999 (10^4hm^2)	Change (%)
Worst (1)	0-2.0	37.36	72.01	4.81
Worse (2)	2.0-4.0	961.62	1558.48	3.83
Moderate (3)	4.0-6.0	4489.48	4005.03	-1.21
Better (4)	6.0-8.0	1742.80	1515.24	-1.50
Best (5)	8.0-10.0	56.76	47.26	-2.01

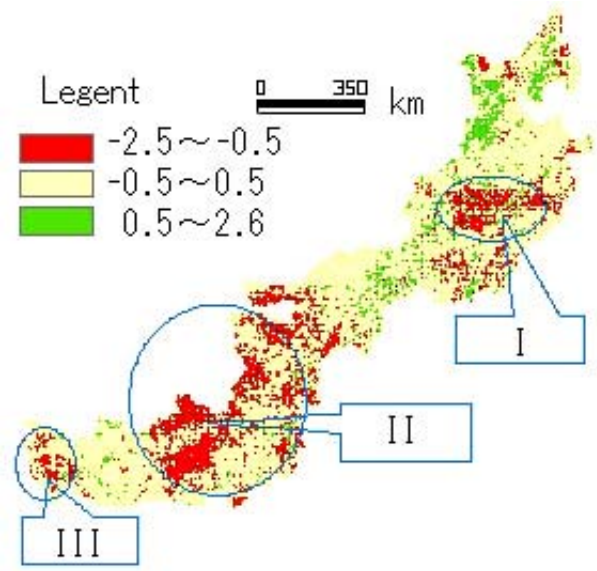
B. Quantitative Change of Eco-environment

The data in different grades of eco-environment in the year of 1989 and 1999 are shown (Table 1). The third, fourth and fifth grade are the main part of regional eco-environment background condition. In 1989 the percentage of these three grades are 61.60%, 23.91%, 13.19% respectively and 54.95%, 20.79%, 21.38% in 1999, meanwhile the percentage of the other two grades are less than 2.0%.

There are three marked characteristics of the structure change of regional eco-environment background condition from 1989 to 1999. The first one is: the total area of the region which regional eco-environment background condition are moderate, better or best are decreasing largely, on the contrary the area of the other two grades are increasing through the change isn't very obvious. The second characteristic is: the region that its area increasing most largely is the second grade (the eco-environment background condition of this grade is worse) with an area increase of 596.8610^4hm^2 and 38.29%; the region that its area decreasing most largely is the third grade (the eco-environment background condition of this grade is moderate) with and area increase of 484.4510^4hm^2 and 12.19%. The third characteristic is: using the dynamic degree to express the changing speed of each grade of eco-environment background condition, the results show that the dynamic degree of the first grade increases fastest and the fifth grade decrease fastest too. This phenomenon indicates the eco-environment in the farmland-pastoral region of the northern China is deteriorating gradually, so does the living environment of human beings.

C. Regional Changes of Eco-environment

The mutative value and its direction of eco-environment background condition of each grid can be obtained by using the eco-environment background condition index of 1989 minus those in 1999. The results show that the mutative value of each grid's eco-environment background is between -2.5-2.6 (Figure4). The negative value shows that the eco-environment background condition is deteriorating gradually and the positive value is contrary. The value between -2.5--0.5 was defined as the region eco-environment background condition is getting worse, the value between -0.5-0.5 indicate the condition is changing slightly, and the value between 0.5-2.6 as the region eco-environment background condition is getting better and better, then a thematic map about the changes of eco-environment background condition is created. There are also 2 marked characteristics can be found in the changes of eco-environment background condition from 1989 to 1999. (1) The changes of eco-environment background condition nearly cover all over the farmland-pastoral region of the northern China. (2) The deteriorations of eco-environment background condition mainly occurred in the adjacent area of Jin-Shan-Meng-Gan-Ning, Horqin desert and its outer area and the east of Qinhai province. Moreover there is a large range of changes in these regions.



I: the Horqin desert and its outer area
II: the adjacent area of Jin-Shan-Meng-Gan-Ning
III: the east of Qinhai province

Figure4. CHANGES OF ECO-ENVIRONMENT (1989 –1999)

VI. CONCLUSIONS

By selecting land cover, topography and meteorological conditions these three spatial thematic data, the paper makes a comprehensive evaluation on the eco-environment background condition of 1989 and 1999 in the farmland-pastoral region in the northern China by using the digital grid. The change model of eco-environment background condition is built in order to analysis the spatial distribution, quantitative change, the trend of change, the change region and the dynamic spatial pattern of eco-environment. The results of assessment are accordant to the current situation. This case is helpful to make use of spatial technique in monitoring the change of eco-environment background condition and is supplied to make scientific decision in eco-environment protection.

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